THE

AMERICAN REPERTORY

OF

ARTS, SCIENCES, AND USEFUL LITERATURE.

Vol. II. August, 1831. No. 8.

CHEMISTRY.

Definition.—Chemistry is the science which teaches the nature of bodies; or rather, the mutual agencies of the elements of which they are composed, with a view to determine the nature, proportions, and mode of combination, of these elements in all bodies.

History.—Until the year 1650, we find little worthy of notice in the history of chemistry. Previous to this period early inquirers, instead of passing from what was known to what was unknown, suffered themselves to be led astray by astrological dreams, the fables of the philosopher's stone, and a hundred other absurdities.

Alchymy. The alchymists had in view, three great objects of discovery, viz.—1st. The *Elixir of Health:* by the use of which the lives of men might be protracted to any desirable length, or their mortality prevented. 2nd. The *Universal Solvent*, or a liquid which should dissolve every other substance. This, it was supposed, would lead to the grand discovery. 3d. The *making of gold*, or finding the *Philosopher's Stone.* Their theory was, that a perfect metal consisted of *quicksilver* and *sulphur;* these, when pure and united, formed gold. That all other metals contained a quantity of dross, which prevented the particles of these two substances from uniting. If, therefore, this dross could be got rid of in the other metals, gold would be the result. In 1650 Rhazis, Roger Bacon, Arnaud de Villeneuve, Basilius Valentin, Paracelsus, Agricola, &c. observed some of the properties of iron, quicksilver, antimony, ammonia, and salt-petre. They discovered sulphuric and other acids, the mode of rectifying spirits, preparing opium, jalap, &c. and of purifying the alkalies. Stahl appeared, and, though

Stahl's theory.

his theory was unsatisfactory, and, as later observations have proved, erroneous, yet he laid the foundations of a regular science. He supposed bodies to contain a combustible element, which inflammable bodies lost by being burned, and which they could gain from other more inflammable bodies. Boerhaave, the founder of philosophical chemistry, which he enriched with many experiments in regard to fire, caloric, light, &c. adopted Stahl's system. It was reserved for Black, Priestley, Cavendish, and Lavoisier, to overturn Stahl's system, and substitute the pneumatic chemistry. Oxygen now took the place of phlogiston, and explained the difficulties which beset the phlogistic theory. The commencement of the 19th century forms a brilliant era in the progress of chemistry. With the galvanic apparatus of Volta, Sir Humphrey Davy commenced a series of researches, which resulted in a greater modification of the science than it had ever before experienced. That department of chemistry, relating to the definite proportions in which bodies unite to form the various chemical compounds, has been most successfully investigated. The multitude of exact analyses requisite to establish the conclusions arrived at, were accomplished mostly through the labours of Vauqueline, Guy-Lussac, Thénard, Berzelius, and Thompson; and terminated in the establishment of the general truth, that bodies combining chemically and intimately with each other, combine in determinate quantities; and that one body, combining with another in more than one proportion, the ratio of the increase may be expressed by some simple multiple of the first proportion. Upon this general fact, Dr. Wollaston constructed the logametric scale of chemical equivalents. The doctrine of definite proportions has, therefore, communicated to the principles of chemistry, that certainty which has long been considered peculiar to the mathematical sciences; and it is in the developement of these important relations, that the advancement of the science has been most conspicuous.

Pneumatic system.

Davy's researches.

Definite proportions.

Philosophical chemistry, explains the affinity of aggregation or cohesion, and the affinity of composition or chemical affinity. It treats of solution, saturation, crystallization, ebullition, fusion, and neutralization. It shows that affinity may be exerted, 1. Between two simple bodies; —2. Between a simple and a

compound one;—3. Between compound bodies. It establishes the principle, that bodies attract each other unequally; the laws which determine this, and the circumstances which modify it; such as cohesion, mass, insolubility, elasticity, and temperature. It measures the degree of affinity both of simple and compound bodies; that bodies act upon each other only at imperceptible distances; that two bodies, having no perceptible affinity, may be made to combine by the interposition of a third; and, finally, that combination destroys the peculiar properties of bodies, and the compound possesses entire new ones.

Divisions.—Chemistry is divided into seven or eight branches.

Meteorological chemistry.—The study of the phenomena called meteors, constitutes *meteorological* chemistry. This explains clouds, rain, mist, &c. and, in short, all the chemical processes going on above the surface of the earth.

Geological chemistry, treats principally of the great combinations of nature which produce volcanoes, veins of metal, beds of mineral coal, mineral waters, the enormous masses of salt and lime, the salt-petre in the bed of the Indus, the natron of the lakes of Egypt, and the borax of the lakes of Thibet.

Physiological chemistry, treats of the changes produced in animal substances, by the operation of life.

Pathological chemistry, traces the changes produced by disease or organic defects.

Therapeutic or *Pharmaceutic* chemistry.—This teaches the nature and preparation of medicines, and the means of preserving them.

Hygietic chemistry, teaches us the method of arranging our habitations so as to render them healthy; of guarding against contagious diseases, &c.

Agricultural chemistry.—This treats, 1. Of the general powers of matter, which have any influence on vegetation; of gravity, cohesion, &c. 2. Of the organization of plants, their structure, and the substances found in them;—3. Of soils;—4. Of the nature of manure.

NOMENCLATURE.—Twelve or fifteen terms have been found sufficient for creating a methodical language, in which there is no inexpressive term, and which, by changing the final syllable of certain names, indicates the change which takes place in the composition of the bodies. Bodies not acid to the taste, and having the property of turning blue, what has been reddened by

Termination. ide. acids, have the termination *ide*, as *oxide, chloride*, &c. If the supporter of combustion unites with the combustible in only one proportion, we call this compound simple, the *oxide, chloride*, &c. If they unite in several proportions, we call the first, containing the *Prefixes.* smallest proportion of oxygen, &c. *protoxide*, &c.; the second, *deutoxide*; the highest, *peroxide*. One *Termination. ic.* acid only being formed, receives the name of the combustible, with the termination *ic*. Thus carbon and oxygen form *carbonic* acid. Several being formed, that containing the larger proportion of the acidifying principle, terminates in *ic*, and that con- *ous.* taining the less in *ous*. Thus sulphur forms *sulphuric*, and *sulphurous* acid. To intermediate com- *hypo.* pounds we annex *hypo*, (meaning less,) designating a less degree of acidity. Thus we have *sulphuric* and *hypo-sulphuric*. The combustible in acids, oxides, &c. is called the *base*. For the names of compounds of two binary burnt bodies, no rules have been adopted to express the union of two oxides, two acids, or an acid with a non-metallic oxide. We call those formed of acids and metallic oxides, *salts*; and to form their individual names, we change the termination of the acid, and place it before the name of the *ite* and *ate.* metal; *ous* becomes *ite*, and *ic* becomes *ate*; sulphurous acid and oxide of tin, form *sulphite of tin*; sulphuric acid and tin, *sulphate of tin*. The same acid combining with more than one oxide of the same metal, we prefer the characteristic of the oxide, to the name of the acid; thus, sulphuric acid, with the protoxide of iron, forms the *proto-sulphate* of iron. Other substances also unite with acids, neutralize them, and form compounds analogous to salts. There are no general rules for the names of these compounds; the substances themselves are called *salifiable bases*. In the combination of combustibles, the rules of nomenclature vary: 1. If the constituents are metals, they form *alloys*. 2. If the compounds are solid or liquid, and formed of a metallic and a nonmetallic combustible, we give to the latter the ter- *uret.* mination *uret*; as carbon with iron forms carburet of of iron. If both be non-metallic, the termination *uret* may be attached to either, as *phosphuret of sulphur*, or *sulphuret of phosphorus*. 3. If the compound is gaseous, we name the gas, or one of the gases, if it is composed of two, and join the other component as an adjective; as *phosphureted hydrogen*.

Analysis *and* Synthesis. Chemistry has two ways of becoming acquainted with the internal structure of bodies, *analysis* and *synthesis*, (decomposition and combination.) The former separates the component parts of a compound body; the latter, combining the separated elements, forms anew the decomposed body, and proves the correctness of the former process.

Attraction *and* Repulsion. All the phenomena of the material universe may be resolved into two kinds of motion, viz. *attractive* and *repulsive*, by which the particles of matter approach or recede according to known laws, but from unknown causes. These principles operate in two modes; in the first, they communicate motion to *masses* at *sensible* distances; in the second, to *atoms* at *insensible* distances. To the former mode, belong the attractions of gravitation, electricity, and magnetism; to the latter, the attraction of cohesion. In chemistry, the observation of these principles is limited to the study of their effect upon particles of *different* natures at *insensible* distances. The attraction of cohesion between particles of the *same* nature, as also its opposite, the power of repulsion, are both opposed to chemical attraction, which exists between particles of *different* natures.

Affinity.—The power which determines the union between particles of different natures, is termed chemical affinity, of which there are three kinds, viz. mixture, solution, and composition.

Mixture.—Chemical mixture can only take place between bodies whose particles are in a like state, and when cohesion is so far suspended that motion may take place between the particles of each. Liquids, or fluids, may be mixed; but solids can only be mixed when heat has brought them to a state of liquidity. Some fluids, however, have no affinity, as oil and water. Aeriform fluids, as the various gases, mix with facility, because there is no sensible cohesion between their particles to be overcome by affinity. Chemical mixture may take place between bodies in any proportions; and it is often attended by condensation of volume, and increase of temperature. The properties of the bodies will not be materially changed; the mixture will combine those of the component parts, the more active ingredient predominating according to its quantity. The separation of liquid mixtures may be effected either by adding or subtracting heat: the addition of heat will turn one ingredient into va-

pour, which may be recondensed, while the other is left pure; the first part of this process is termed evaporation; the whole is termed distillation: the subtraction of heat converts one body into ice, which may be re-melted after the other has been separated in its liquid state. Gaseous mixtures cannot be thus separated, for they expand or contract in the same degree; but vapours may be separated from gases by condensation.

Solution.—This is the result of affinity between bodies that are unlike in their degree of cohesion, as solids and liquids. In this case the liquids are called solvents, and they can hold in solution either solids or aeriform fluids. Between some of these different kinds of bodies, however, there appears to be no affinity, or at least it is inferior to the attraction of cohesion.

Chemical attraction may be exerted in different degrees between one body and several others: thus, if to a solution of two bodies, a third be presented, it may unite with either of the two, while the other will become detached from both, and resume its original form: this has been called elective attraction, and the resumption of the solid form, precipitation. Liquids cannot combine with more than a certain quantity of any solid or aeriform body; and the point at which the action of the solvent ceases, is called the saturating point. The application of heat to a solid body increases the action of the solvent upon it, by lessening its cohesion; while it lessens the action upon an aeriform body, by increasing its elasticity. A solvent is capable of holding more than one body in solution at the same time. The solution of solids frequently produces cold, while the solution of gaseous bodies generally evolves heat. Solution does not change the properties of bodies, and the character of the compound is intermediate between its ingredients. Solutions may be disunited, like mixtures, by the application of heat or cold: if the solvent contain a solid body, heat will drive off the liquid in the form of a vapour: if it hold a gaseous body, heat will drive off the gas, or cold will freeze the liquid, and the gas will escape.

Composition.—Composition is the result of the highest degree of chemical attraction, which may take effect between bodies whose particles are under every modification of cohesion. The union of bodies in this manner takes place only in definite proportions, and is accom-

panied by a total change of their sensible properties, and by alterations of temperature; light and heat are frequently given off, and often with violence. Bodies may unite in more than one proportion, but still the proportions are always definite, being some multiple, or sub-multiple, of the first compound. Substances, comparatively inert, may produce by their union, compounds of highly active properties; and highly active bodies, of opposite properties, may produce by their combination, substances of a mild character; in this case they are said to neutralize each other. If, to a compound of two bodies, a third be presented, which has a stronger affinity for either of the two bodies, than they have for each other, decomposition will take place, and a new compound be formed: this action is termed *single elective affinity*. If two compounds be brought together in solution, double decomposition and double composition frequently take place, termed *double elective affinity*, and two new compounds are formed, owing to a new adjustment of affinities. In these new compounds each ingredient will be found exactly equivalent to the others: as the ingredients of each of the original compounds are united in a certain definite proportion, so that proportion is precisely sufficient for the fellow ingredients forming the new compounds; and when any body, compounded of two simple substances, enters into combination with another body, the sum of the equivalents of the two elements will give the number denoting the proportion in which it will combine. The minor affinity of solution, is frequently necessary to enable composition to take place: and in comparing the attraction of two bodies for a third, a weaker affinity in one of the two, is found to be compensated by increasing its quantity. Alterations of temperature sometimes favour composition, by counteracting the cohesion of solids, and sometimes retard it by increasing the elasticity of gaseous bodies.

DECOMPOSITION.—This is produced by chemical repulsion, which may be sometimes excited by heat; but the most usual and effective agent is the voltaic pile, which, by communicating electricity to the ultimate particles of bodies of unlike kinds, counteracts the strongest chemical attraction. In decomposing substances, those which pass to the negative pole of the voltaic battery are termed *electro positive* bodies; and those which pass to the positive pole are termed *electro ne-*

gative bodies; because bodies that are in opposite states of electricity attract each other.

Compound bodies. All bodies that, on being submitted to the action of the voltaic battery, can be decomposed into other substances, are termed *compound.* All compound bodies can be resolved into thirty-eight elements or simple substances. Of these thirty-eight, but few enter into the composition of most of the substances that are much used in the arts or agriculture.

Elementary bodies. Bodies that cannot be decomposed are termed *elementary* or *simple* substances. Of these, there are fifty-seven, all of which, with the exception of affinity, are simple material substances, differing in some respect from every other body. Affinity is rather a property of matter, than matter itself; and light, heat, and electricity, are yet involved in some uncertainty, being the most subtle agents in the universe, and of an impenetrable nature; but late discoveries render it probable that they are substances. In the following list, those thirty-eight substances which enter into the composition of bodies that are used by mankind, will be found printed in Italics.

Class 1.—Powers.—Affinity, (a general property of nature,) *Caloric, Electricity, Light.*

Class 2.—Acidifying Substances.—*Oxygen, Chlorine, Fluorine, Iodine.*

Class 3.—Acidifiable Substances, not Metallic.—*Hydrogen, Nitrogen, Sulphur, Phosphorus, Carbon, Boron, Selenium.*

Class 4.—Metalloids.

Section 1.—The bases of alkalies and of alkaline earths. Of *Potash*, of *Soda*, of *Lime*, of *Barytes*, of *Strontian*, of *Magnesia*, of *Ammonia*, of *Lithia.*

Section 2.—The imaginary bases of non-alkaline earths. Of *Silex*, of *Alumine*, of *Glycine*, of *Zircon*, of *Yttria*, of *Thorina.*

Class 5.—Metals.

Section 1.—Those which absorb oxygen with such force as to decompose water when heated sufficiently. *Iron, Manganese, Tin, Zinc, Cadmium.*

Section 2.—Those which absorb oxygen, but not with sufficient force to decompose water. (Some are capable of becoming acids.) *Arsenic, Chrome,* Molybdenum, Tungsten, Columbium. (Others are not capable of becoming acids.) *Copper, Antimony, Bismuth, Cobalt,* Titanium, Tellurium, Cerium, Uranium.

Section 3.—Those which receive oxygen artificially from the de-

composition of strong acids only. ***Gold, Silver, Platina, Palladium,*** Osmium, Rhodium, Iridium.

Section 4.—Those which absorb oxygen at limited temperatures, and give it wholly off at higher temperatures. ***Mercury, Lead, Nickel.***

CLASSES OF CHEMICAL PRINCIPLES.

CLASS 1.—POWERS.

PRINCIPLE 1.—AFFINITY.—Affinity is an universal property of matter; consequently, it is in all places where matter is found. The term affinity is limited exclusively to heterogeneous attraction; that is, when dissimilar particles or atoms are compounded together. Affinity is simple or elective in its effects, according to its applications; though the principle is a single one and uniform in its operation.

Simple affinity. Simple affinity, is that application of affinity whereby the atoms of a compound body are united without causing decomposition. Illustration: if olive oil be poured into water, no mixture will take place; but if pearlash be added, a combination will be effected, which will produce white soap. Rationale: water and oil having no affinity, repel each other; but they have affinity for alkalies; therefore the pearlash unites with itself both the water and oil. Application: by this principle, soft soap is made with oil or soap-grease, potash, and water—hard-soap, with oil, soda, and water; and volatile liniment, with ammonia, olive oil and water.

Elective affinity is either single or double.

Single elective affinity.—This is that application of affinity, whereby the atoms of a new compound, by the force of their attraction, exclude others from a previous state of combination. Illustration: if dry table salt, (which is composed of muriatic acid and soda,) be mixed with sulphuric acid, the muriatic acid of the salt will escape in the form of gas, while the sulphuric acid will unite with the soda of the salt and form Glauber's salts.

Double elective affinity.—This is that application of affinity, whereby neutral compounds decompose each other, and form new neutral compounds. Illustration: if four parts of muriate of lime, and five parts of sulphate of soda, be dried, separately dissolved in water, and then mixed, sulphate of lime will be precipitated to the bottom, and a solution of muriate of soda, or common salt, will stand over it. Rationale: the muriatic acid

unites with the soda, and the sulphuric acid unites with the lime.

Definite proportions. When substances unite by affinity in definite proportions, their properties and sensible qualities are changed.

Indefinite proportions. When substances unite by affinity in indefinite proportions, their properties and sensible qualities are not changed.

PRINCIPLE 2.—CALORIC.—Caloric is contained in all bodies upon the earth, and probably throughout the universe. Bodies which we term cold, as ice, still contain caloric in combination. All gases and liquids would become solids if their caloric were extracted: all solids and liquids would become gases if their caloric were sufficiently increased.

Combined caloric.—Latent or combined caloric, which does not excite the sensation of heat, may become sensible by compression. Illustration: if tinder be put in the end of the piston of the fire-syringe, the tinder will take fire upon suddenly forcing down the piston. The tinder should consist of cotton cloth dipped in a solution of salt-petre. Latent caloric may be brought to the free state, by mixing liquids which strongly attract each other. More caloric is required for converting liquids into vapour or gas, when the liquids are subject to atmospheric pressure, than when that pressure is taken off. Illustration: if water be made to boil in a Florence flask, and the flask be corked before being taken from the fire, the water, when cooled, may be made to boil, by setting the flask upon ice, snow, or in cold water; and, if held again over the coals before the cork is taken out, it will not boil.

Caloric enlarges the volume, and thereby diminishes the specific gravity of a gas, by entering into, and combining with it, and passes from one body into another, which contains less in proportion to its capacity for caloric, until the two bodies are in equilibrio.

Expansive power. Caloric expands solids, liquids, and gases, by entering into, and combining with them.

Conductors. It is transferred through bodies called conductors, which differ greatly in their conducting powers; and all substances are better conductors, if dark-coloured or rough, than if bright, polished, or light-coloured. When solids are converted into liquids, caloric is absorbed from the adjoining bodies. When liquids are converted into vapour or gas, caloric is absorbed from adjoining bodies. When liquids become solids,

or vapour, or gases, become liquids, solids, or denser vapours, latent caloric is evolved, and becomes free. Free caloric is radiated in all directions, like light, from the body from which it is disengaged; and it is likewise reflected by hard polished surfaces.

PRINCIPLE 3.—ELECTRICITY.—The electric fluid is universally diffused. It presents no phenomena which indicate its presence, when in equilibrio. When its equilibrium is disturbed, and it is seeking its restoration, it exhibits several interesting properties. The electric fluid is accumulated by friction, and manifests itself by attraction and repulsion. Illustration: rub a glass cylinder, a stick of sealing wax, or a piece of rosin, with a dry silk handkerchief, and they will attract and repel, alternately, pieces of cork, feathers, tow, thread, &c. suspended by a silk; the substance should be warmed, and the experiment made when the atmosphere is dry. Rationale: the electric fluid being accumulated by friction, makes an effort to pass off, to restore its equilibrium; in doing which, it attracts those bodies; after being a short time in contact, electrified bodies repel each other. The electric fluid is accumulated by the action of diluted acids upon pairs of metallic plates, and tends to restore its equilibrium in the direction of the metal which has the strongest attraction for oxygen. This application of electricity is called *galvanism.*

Compounds, of which one of the constituents is oxygen, may be decomposed, if placed in a galvanic circle, the oxygen always going to the positive side.

Galvanic circle. The galvanic circle is a trough of wood divided into half inch portions, by metallic partitions, composed of plates of zinc and copper, soldered together, and set in with the same metals the same way. Fill these portions with a mixture composed of one part of sulphuric acid, one part of nitric acid, and sixty parts of water. Fit in a wire at each end of the trough, by coiling one end spirally, so that it will spring strongly against the two extreme metallic plates: when the other ends of the wires are brought near together, sparks will pass from one to the other. If a recently dead animal be placed in the circle, with the wires touching a nerve and a muscle, it will exhibit signs of life. Metals will burn like tinder, and all compound substances will become decomposed.

PRINCIPLE 4.—LIGHT.—Light is chiefly derived from the sun; this

is called solar light: it is also derived from terrestrial objects; this is called terrestrial light. Light is generally accompanied by caloric. Every ray of common light contains seven different kinds: these seven kinds differ in two ways, viz. by a difference of light and of refrangibility. They are red, orange, yellow, green, blue, indigo, and violet. The red is least refrangible, the violet most. The different colours of bodies depend on the different kinds of light which they reflect to the eye: bodies will therefore appear of that colour for which they have no affinity. White bodies reflect all kinds of light; black reflect none. The different kinds of light are reflected according to the arrangement, not to the nature, of the atoms of bodies. Light decomposes many substances by its direct action upon their elementary constituents. Light is radiated from many substances, which seem not to belong to the class of luminous bodies; such light is denominated *phosphorescent* light.

CLASS 2.—ACIDIFYING SUBSTANCES.

PRINCIPLE 1.—OXYGEN.—Oxygen is very generally diffused, though not so universally as caloric, electricity, and light. It is one of the constituents of the atmosphere; composing about 21 per cent. of it. It is the only souring or acidifying principle used in nature; and probably so in artificial preparations. It is found in nature in the solid, liqueous, and gaseous state; but when pure, it is always in the gaseous state. It is combined with most of the metals in a solid state, forming what are oxyds of metals, and also acids in a few cases; as the ores called oxyd of iron, oxyd of manganese, &c.; chromic acid in the chromate of iron, &c. It is combined with hydrogen in the liquid state, forming water; and with carbon in the gaseous state, forming carbonic acid gas. The same acid is solid in a triple compound, as in the common marble, which consists of carbonic acid and lime. In the state of combination, oxygen is found solid in primitive, transition, and secondary rocks. Therefore, the ocean, the air, and the earth, abound in it. Oxygen is found in great abundance, in combination with metals, from which it may be disengaged by caloric in the state of gas.

Some acids hold their highest proportion of oxygen by so feeble a tenure, that though combined with a

base in the state of a salt, they will give it off in a state of gas, when but slightly heated.

Oxygen is the only supporter of combustion in the atmosphere. Rationale: a candle will not burn in nitrogen, but will, after the introduction of oxygen; it is therefore manifest, that it is oxygen which supports combustion.

Application: when much of the oxygen has been consumed by the breathing of a crowded assembly in a close room, candles do not burn in the room with the same brilliancy. Oxygen promotes combustion vehemently, when pure. Rationale: oxygen being mixed with nitrogen in the atmosphere, and nitrogen not being a supporter of combustion, the strong action of the oxygen, as a supporter of combustion, is restrained. Application: if the atmosphere were pure oxygen, all combustible substances, when once inflamed, would burn without control, to the destruction of all the living beings inhabiting the earth. Some metals will burn vehemently, after being inflamed, in oxygen. Oxygen is the acidifying or souring principle.

PRINCIPLE 2.—CHLORINE.—Chlorine is an artificial substance. If simple, it exists in nature in a state of combination with hydrogen, forming muriatic acid. Whether simple or compound, has been a subject of much discussion. If compound, it must be a compound of muriatic acid and oxygen. Muriatic acid is the substance in which we are to consider the natural history of chlorine; for chlorine is obtained from it, either by adding oxygen to it, or by divesting it of its hydrogen. Muriatic acid being one of the constituents of common salt, it is as extensive as the waters of the ocean, the waters of salt springs, and the mines of solid salt.

Muriatic acid.

Chlorine is obtained in the state of gas, from common table salt, by the aid of the oxyd of a metal, and a strong acid. Chlorine gas feebly supports combustion, and inflames some substances spontaneously.

Chlorine extinguishes vegetable colours, if the substances to be operated upon are moistened, or if the chlorine is in a liquid state.

Muriatic acid, from which chlorine is made, is obtained from common table salt, by elective affinty. It is strongly absorbed by water or ice. Muriatic acid gas extinguishes flame, first enlarging it and

giving it a green tinge. Muriatic acid may be arrested in water standing over common salt, at the moment of its escape, forming the liquid spirits of salt, or the muriatic acid of the shops.

Principle 3.—Fluorine.—Fluoric acid is chiefly formed in combination with lime, constituting the fluor spar. From its analogy to other acids, it was supposed to have an acidifiable base, which is combined with oxygen. This base was never discovered. The acid so nearly resembles the muriatic acid, that it seemed necessary to suppose, that it consisted of hydrogen and a simple substance analagous to chlorine. Therefore, to accommodate the chloridic theory, a fluorine is assumed, with little or no evidence.

Fluoric acid has been found in topaz, and in a few other minerals; but it is always obtained from fluor spar, when used in the arts.

This acid dissolves flint and glass. It is found constituting an essential part of fluor spar, from which it may be obtained in the state of gas, by elective affinity.

Principle 4.—Iodine.—Iodine is obtained from barilla, (the coarse impure soda,) or from the sea-weeds from which the barilla is obtained. Whether it exists as a ready formed simple substance in the sea-weed, or whether it is a compound, produced in the process of obtaining it, is not known. It possesses several properties in common with chlorine. Being always in connection with muriatic acid, it may be a compound of that substance. But as it has not yet been decomposed, it is treated as a simple substance. Iodine, at the common temperature, is in the state of solid scales, of a steel-gray colour. In this it differs from chlorine, which is in a state of gas when pure. Iodine becomes a purple gas on raising the temperature a little. It gives different colours to different substances.

Class 3.—Acidifiable Substances, not Metallic.

Principle 1.—Hydrogen.—As water is a compound of hydrogen and oxygen, it is as extensively diffused as water. Water of crystallization forms a part of crystals, constituting rocks of all formations, from the oldest to the most recent. Hydrogen is one of the essential constituents of all animal and vegetable matter. It is also found pure. Whatever decomposes water by attracting and uniting with its oxygen, disengages the hydrogen in an uncombined state. It appears,

also, as a production of nature, in the state of several compound gases; such as the sulphuretted hydrogen, a very nauseous scented gas, the carburetted hydrogen, which issues from decaying vegetables, and coal mines, &c. It issues from decaying animal matter, in combination with nitrogen, forming ammonia.

Hydrogen and oxygen being the combined constituents forming water, if the oxygen of the water is united to a metal, by elective affinity, the hydrogen will come over in the state of gas. Hydrogen gas burns in a continued blaze, when passed from any vessel into atmospheric air. It explodes if inflamed when intermixed with oxygen—very violently if the oxygen is pure, and considerably when the oxygen is combined with nitrogen, as in atmospheric air. This gas, though itself combustible, will not support the combustion of other substances. Application: the distinction between a combustible substance and a supporter of combustion, should be well settled in the mind. Hydrogen and oxygen are good specimens of both. Hydrogen and oxygen, when united by combustion, form water. While hydrogen is burning in oxygen, it excites vibrations in a glass vessel, producing sounds. Hydrogen is much lighter than atmospheric air. Water absorbs and holds in combination a quantity of atmospheric air. On freezing, water expands its volume, and thereby diminishes its specific gravity. Its specific gravity is increased by dissolving a salt in it.

PRINCIPLE 2.—NITROGEN.—Nitrogen is one of the two constituents of the atmosphere; composing about 79 per cent of it. Nitrogen and oxygen are the only essential constituents of the atmosphere; though other gases, as well as aqueous vapour, are always suspended in it. Nitrogen is an essential constituent of salt-petre, from which it derived its name. It is also produced in a pure state from the earth at New Lebanon springs, and in Hoosick, in the state of New York. Nitrogen and oxygen being the only essential constituents of atmospheric air, if the oxygen be abstracted from an enclosed portion of the atmosphere, the nitrogen will be left in the state of gas. Nitrogen gas extinguishes flame, and destroys life, if breathed, by excluding oxygen. This gas is the lightest of the constituents of atmospheric air. Nitrogen is found combined with its highest proportion of oxygen in the

salt-petre, from which it may be obtained by elective affinity.

Nitrous Acid. Nitric acid may be reduced to nitrous acid and nitric oxyd, by yielding part of its oxygen to a metal.

Nitrous Oxyd. It may be reduced to nitrous oxyd (the exhilirating gas,) by heating it, when chemically combined, with ammonia.

Hartshorn. Nitrogen and hydrogen combined, form an alkaline compound, called ammonia, hartshorn, or volatile alkali.

Principle 3.—Sulphur.—Sulphur is very abundant in nature. It is generally found in combination with a metal, which is called a sulphuret. In combination with iron, called iron pyrites, it is found in every rock, from the oldest granite, to the most recent secondary rock.

From its combination with this metal and with copper, the brimstone of the shops is obtained, by the process called sublimation. It is found in combination with lead, zinc, silver, mercury, &c. It is also found pure in Italy and in other volcanic districts. It is inflammable and electrical. It is tasteless and inodorous when pure; but on combining with oxygen by combustion, or by heat or warmth below combustion, it gives off a disgusting odour, or suffocating gas. It crackles by the warmth of the hand. It may be crystallized by melting, and then by pouring out the melted interior of the mass, just at the precise time the exterior is beginning to be covered with an incrustation, by cooling. The crystals are acicular.

Sulphurous acid gas. Sulphur, on being inflamed in atmospheric air, will unite with a definite proportion of oxygen, and form sulphurous acid gas.

Sulphuric acid. On being inflamed in atmospheric air, if previously pulverised, and mixed with a portion of salt-petre, it will unite with its highest definite proportion of oxygen, and form sulphuric acid, or oil of vitriol.

Sulphuretted hydrogen gas. It may be combined with hydrogen, and form the essence of most of the nauseous scents, called sulphuretted hydrogen gas. This is the gas which is generated in all dirty sinks, and other places abounding in such filthy substances.

Sulphuretted hydrogen gas explodes on being inflamed in oxygen. It is rapidly absorbed by water; and, in the liquid state, gives a dark or black tinge to many metals.

Principle 4.—Phosphorus.—Phosphorus, the most combustible of all simple solids, is always found in nature in the state of an acid; mostly forming a salt with lime.

Bones of animals consist chiefly of phosphoric acid and lime.

Phosphate of lime, a compound similar to animal bones, is found in the oldest granite; though rarely in transition or secondary rocks.

Oxyd of Phosphorus.

Phosphorus slowly decomposes water, by combining with a little oxygen, forming the oxyd of phosphorus. By light friction it becomes oxydated, and during the process a partial combustion and illumination takes place. Illustration: rub a stick of phosphorus lightly on a board. The phosphorus which is left on the board will be luminous in the dark, and by blowing upon it, undulating waves of light will appear and vanish. Application: letters, or even sentences, written on board ceilings, may be read in the dark for fifteen or twenty minutes. During their illumination, the phosphorus is manifestly in a state of imperfect combustion, and becomes oxydated.

Phosphoric acid.

Phosphorus, on being inflamed in atmospheric air, will unite with its highest definite proportion of oxygen, and form phosphoric acid. It may be inflamed under water by furnishing it with a due portion of oxygen. This may also be made to unite with hydrogen, forming a compound which explodes and burns spontaneously in atmospheric air, called phosphuretted hydrogen gas.

Phosphuretted hydrogen gas.

This is an exhibition of the jack-o'lantern, so often seen about places where animals are putrifying in damp ground. But nature has a method of combining the phosphuretted hydrogen with something, which causes it to burn more steadily, and to endure longer.

Phosphuretted hydrogen gas explodes spontaneously, and with great brilliancy in oxygen gas. Phosphorus dissolves in warm oil, and in that state is luminous in the dark, when exposed to atmospheric air. Illustration: fill an ounce vial two-thirds full of sweet oil. Put some shavings of phosphorus into it. Hold the vial near the fire, until it is about as hot as can be borne by the hand, and keep it at this temperature until the phosphorus is melted. If the cork be now taken out, the upper part of the vial will become luminous in the dark by the admission of air. Cover all the lights in the room, pour two or three tea-spoonfuls of it into the hand, and rub it thoroughly over a boy's face and hair. His face will be singu-

larly luminous, and his hair will exhibit a kind of undulating flame.

Principle 5.—Carbon.—Carbon is pure in the state of a diamond only. Common charcoal is always combined with a little oxygen. Carbon is abundant in nature in various states. In the pit coal, it exists in combination with a little oxygen, bitumen, sulphur, &c. In the anthracite, or glance coal, it is more pure than in any other state, excepting the diamond. Combined with oxygen, in the state of gas, it floats in the atmosphere. It forms a constituent part of marble, of chalk, of all vegetable and animal matter, &c.

Carbonate of lime is found disseminated in granite; therefore, carbon is associated with the oldest rocks in the solid state, while we give off portions of it from our lungs, in the state of gas, at every respiration.

Charcoal, when cold, absorbs sulphuretted hydrogen gas, ammoniacal gas, carburetted hydrogen gas, carbonic acid gas, &c. and gives them off again when heated. A tooth-powder, made by heating finely pulverized charcoal to redness, in an iron skillet, and pouring it while hot into a bowl of clean water, is the best of all known substances, to preserve the teeth from decay, or to prevent further decay after it has commenced. Putrid meat will become purified by immersing it in a similar preparation. Putrid water is also purified by pouring into it heated charcoal powder, &c. &c. Carbonaceous manures, as rotted straw, leaves, &c. furnish food for vegetables upon the same principle. In the cool season of night they absorb carbonic acid, carburetted hydrogen, ammonia, &c. which they give off under the heating rays of the sun, during the day, to the absorbent vessels of the fibrous roots of plants.

Carbonic acid gas.

Charcoal, if exposed to oxygen gas, in a state of ignition, will combine with it, and form carbonic acid gas. A kettle of burning coals, is frequently set into a close bed-room, on a cold night. Carbonic acid gas is formed by the union of the charcoal with the oxygen of the atmosphere, which frequently destroys life.

Carbonic acid, exists in combination with lime, forming chalk, common limestone, or marble, from which it may be obtained by elective affinity. Carbonic acid gas is absorbed by water, and in that state of combination gives the acid test. It is heavier

than atmospheric air, extinguishes flame, and destroys life when breathed. This is the gas found at the bottom of wells and mines, frequently producing death. As a test of its existence, a lighted candle may be let down; if the candle burn, life will be preserved; if not, life will be destroyed. This gas may always be found, in a greater or less proportion, suspended in the atmosphere, and it is given out by animals at every respiration.

Carburetted hydrogen gas.

Carbon and hydrogen may be united, forming the light carburetted hydrogen gas, by decomposing water with charcoal. This is called the blue gas, from the colour of its flame. Decaying, or putrefying vegetables in swamps, &c. decompose water and form the same gas, which is generally called marsh miasmata. It appears too in the bottom of stagnant ponds, &c. which may be collected in bubbles, by pressing upon the mulchy sediment. This gas will explode, when inflamed with oxygen. A similar gas is sometimes generated in coal mines, which, coming in contact with the oxygen of the air, often explodes when the workmen go into the pits with candles. But it is found, that if the candle is enclosed by fine wire gauze, called Davy's safety lamp, the gas will not explode.

Olifiant gas.

Carbon and hydrogen may be united, forming a heavy carburetted hydrogen gas, called olifiant gas, by heating alcohol and sulphuric acid together. This is called the white gas, from the colour of its flame. Carbon and hydrogen will unite, partly, as in the light, and partly, as in the heavy carburetted hydrogen gas, by distilling pit-coal with a red heat. This produces the gas used for gas lights. It is called coal gas.

Coal gas.

PRINCIPLE 6.—BORON.—Boron is the basis of boracic acid. The acid is found in the East Indies, Persia, Thibet, &c. combined with soda, forming the salt called borax, or tinkal. It is generally found in lakes. It gives the alkaline test, and is, therefore, called a sub-borate of soda. Boron combined with oxygen in the state of boracic acid, is united to a base of soda, forming borax, from which it may be obtained in solid scales, by elective affinity.

PRINCIPLE 7.—SELENIUM.—Selenium is an extremely rare substance, having been found by Berzelius in very minute quantities, in pyrites from Fahlun, in Sweden. It resembles sulphur more than any other sub-

stance; though it approaches the nature of Tellurium. It is reddish in minute pieces; but its fracture is like lead in larger masses. It melts at a little above the boiling heat of water. After melting, it becomes soft and adhesive like wax. On being heated more highly, it is volatilized in the state of a gaseous oxyd, of the odour of horse-radish.

CLASS 4.—METALLOIDS.

SECTION 1.—BASES OF ALKALIES AND OF ALKALINE EARTHS.—It is now established, that these alkalies consist of peculiar bases, united to oxygen. These bases have some properties in common with metals; but they differ so widely in other properties, particularly in their specific gravity, that they are denominated *metalloids*. The oxygen may be separated from the bases by a very powerful galvanic battery, and some of them by other means.

The alkalies and alkaline earths, consist of peculiar metalloidal bases, chemically combined, with definite proportions of oxygen. They all give the common alkaline tests. That is, they give a green colour to blue, and generally to red vegetable infusions; such as of red cabbage, blue and purple petals of violets, &c. They are all caustic to the taste. They constitute the bases of many important salts, both natural and artificial.

PRINCIPLE 1.—OF POTASH.—As potash is one of the constituents of felspar, (a homogeneous mineral, aggregated with quartz and mica in granite,) it exists in the oldest of the primitial rocks, as well as in animals and vegetables. It is chiefly obtained by lixiviation from the ashes of burned vegetables.

It is also a very abundant production of nature, in the state of the basis of salt-petre.

Potash may be obtained tolerably pure, by abstracting the carbonic acid from pearlash, by the aid of quick lime. It has a strong affinity for all acids, and forms with them neutral salts. Dissolve a small quantity of common potash in a wine glass of water. Prepare another wine glass of very diluted sulphuric acid. Pour into a third glass a little of the infusion of red cabbage. Now drop into the infusion a few drops of the potash, and it will become green, which is the alkaline test. Next, drop diluted sulphuric acid into it very cautiously, and the original colour of the infusion will be restored; which proves that the acid and potash have combined chemically, and

Neutral salts.

Sulphate of potash. formed the neutral salt, sulphate of potash. Add another drop of the acid, and it will become red; which proves that some of the acid is in an uncombined state.

Now more potash may be added, precisely sufficient to take up the excess of the acid, and it will again become as at first. Add a little more, and it will become green. When clothes are spotted with acids, if a solution of pearlash be made, and the spots be wet with it immediately, before the texture is injured, the spots will disappear by the neutralization of the acid, and the clothes will not be injured.

Sulphuret of potash. *Nitrate of potash.* Potash has a strong affinity for all animal matter. It will unite directly with sulphur, and form sulphuret of potash. It may be combined with nitric acid, and form nitrate of potash, called salt-petre.

Nitrite of potash. Nitrate of potash may be reduced to the nitrite of potash, by heating it.

Oxymuriate of potash. Potash is insoluble in pure alcohol. It may be combined with chlorine, or oxymuriatic acid, and form the oxymuriate of potash.

Oxymuriate of potash will communicate oxygen to some combustible substances, by compression, sufficient to inflame them and to produce explosion. To the same principle, all explosive powders owe their powers. *Gunpowder.* Gunpowder is essentially composed of about 75 per. cent of nitrate of potash, 15 per. cent of charcoal, and 10 per. cent of sulphur. These substances are finely pulverized separately, and then intimately mixed. The nitric acid of the nitrate of potash, on being inflamed, parts with so much of its oxygen, as to be reduced to nitric oxyd gas, and part of it to nitrogen gas. *Nitric oxyd gas.* In doing this, oxygen is furnished to the charcoal, sufficient to convert it into carbonic acid gas, and to the sulphur, to convert it into sulphurous acid gas. These solid constituents of gun powder, springing suddenly into the state of these four gases, expand their volume to such a vast extent, as to produce a violent concussion upon the atmosphere, and to impel a leaden ball, or other opposing body, with great velocity.

PRINCIPLE 2.—OF SODA.—Soda often constitutes a part of felspar. Therefore, like potash, it is contained in the oldest primitive rocks. It is found in animals and vegetables; but it is not so abundant in vegetables, as potash. It is very abundant in nature, as the basis of common salt, and is frequently found as the basis of native

Glauber's salts, and Epsom salts, borax, and sometimes in the state of a native carbonate. For commerce, it is obtained by lixiviation from the ashes of burned sea-weeds, and called barilla. It is sometimes called natron. Soda has many properties in common with potash. It gives the alkaline test, is obtained pure in the same manner, unites with acids, animal matter, &c. But its affinity for the acids is more feeble, and it does not diliquesce by attracting vapour from the atmosphere. Combined with oils, it forms hard soap, whereas potash always forms soft soap.

It may be combined with muriatic acid, and form common table salt, muriate of soda. Common salt may be decomposed by potash, so as to afford soda to combine with oil, in the manufacture of hard soap.

Sulphate of Soda. Soda may be combined with sulphuric acid, and form Glauber's salts, sulphate of soda.

Principle 3.—Of Ammonia.—This substance is one of the compounds under nitrogen. Berzelius supposed it might have a metallic base, to be called ammonium. But this hypothesis is not demonstrated. It seems to be proved by Guy Lussac, that it consists of 75 per. cent of hydrogen, and 25 per cent. of nitrogen. It is mostly found in the state of sal ammoniac, (the muriate of ammonia,) in Egypt. It is chiefly manufactured by the lixiviation process, from the excrements of animals which feed on plants growing near the salt water. It has been found near several extinct, or nearly extinct, volcanoes. The pure gaseous ammonia, and the various salts, are obtained from the muriate. Ammonia is obtained in the state of gas from sal ammoniac, by elective affinity. It extinguishes flame after a momentary enlargement of it, and destroys life when breathed. In the state of gas, it will unite with muriatic and carbonic acid gas; with the former, producing the solid muriate, and with the latter, the solid carbonate of ammonia. Carbonate of ammonia may be made by double elective affinity, with carbonate of lime and muriate of ammonia.

Muriate and carbonate of ammonia.

Nitrate of ammonia. This may be formed by combining ammonia with nitric acid.

The liquid ammonia, or hartshorn, is found by absorbing ammonia in water. This is formed by the union of liquid ammonia with sulphuretted hydrogen gas.

Hydro-sulphuret of ammonia.

Principle 4—Of Lime.—Lime, or calcium is very abundant, form-

ing the basis of all lime rocks that are combined with carbonic acid. It is the basis of chalk, coral rocks, and shells. Combined with sulphuric acid, it forms the vast plaster beds of Nova Scotia, and our western districts, and with phosphoric acid, it forms the bones of animals. It has a strong affinity for water: stone lime, in the process of slacking, converting some of the water into a solid, and some into vapour, by the caloric disengaged from the solidified portion.

Hydro-sulphuret of lime.—This is formed by the absorption of sulphuretted hydrogen gas in lime water. Most salts of lime have a strong attraction for water. Lime, combining with carbonic acid, forms carbonate of lime. This carbonate, dissolved in carbonated water, will be deposited when the carbonic acid is abstracted. Lime has a strong affinity for oily substances. Being mixed with silex or alumine, it renders the mixture very fusible.

Carbonate of lime.

It will combine with muriatic acid, and form muriate of lime; which salt, in solution, will change to solid gypsum on adding sulphuric acid. This is formed by combining oxymuriatic acid with lime.

Muriate of lime.

Oxymuriate of lime.

PRINCIPLE 5.—OF BARYTES.—Barytes possesses many properties in common with lime. Considerable quantities in the state of a sulphate, are found in the United States. The most extensive locality, perhaps yet discovered in the world, is that in Carlisle, Schoharie county, New York. This is a fibrous variety, but differs widely in its external character from the fibrous varieties of Europe. All the salts of barytes, excepting the sulphate, are most deadly poisons. By exchanging acids with pearlash, the sub-carbonate of potash, carbonate of barytes may be obtained from the native sulphate. Barytes will combine with muriatic or nitric acid, and form a test for the presence of sulphuric acid.

Carbonate of barytes.

PRINCIPLE 6.—OF STRONTIAN.—Strontian has been lately found by Professor Douglass and W. A. Bird, in great abundance on an island in Lake Erie, in the state of a sulphate. It is found only in a kind of swine-stone, or geodiferous limestone. It is found in geodes in this rock, at Rochester, Lockport, Niagara Falls, on most of the islands in Lake Erie, &c.

The salts of strontian may be distinguished from those of barytes by the colour of its flame when burned with alcohol. These two heavy minerals greatly resemble each other. They are both used for tests, and probably may both be useful as fluxes. They will both combine with sulphuretted hydrogen,

forming hydro-sulphurets; and by heating with sulphur, form sulphurets like all other alkalies.

PRINCIPLE 7.—OF MAGNESIA.—Magnesia forms one of the constituents of the soapstone or talcose rocks, of asbestos, and some other minerals. It is found pure, or merely combined with water, in connexion with soapstone and serpentine rocks at Hoboken, opposite to New York. On Staten island, it is found in the state of a carbonate, in the same range of soapstone or talcose rock. In the state of an efflorescent sulphate, (called epsom salts) it is found in great quantities, six miles north of Troy, on the east bank of the Hudson; also in the same situation at Coeymans, on the west side of the Hudson. It exists in the state of a muriate and sulphate, in sea-water, from which it is obtained by mixing with it a solution of common pearlash. The carbonate of magnesia, thus obtained, is the white magnesia of the shops. The carbonic acid may be driven from its connexion with the magnesia of the shops, by caloric. Magnesia will combine with sulphuric acid, and form epsom salts.

Epsom salts.

PRINCIPLE 8.—OF LITHIA.—Lithia is an alkali, found in a rare mineral, called petalite, by Arfvedson, Berzelius' assistant, in the proportion of 5 or 6 per cent. with about 79 of silex, and 16 of alumine. It approaches soda in its characters; as it forms a salt with muriatic acid resembling common salt in taste, and in its crystalline form. It dissolves very slowly in water, giving off heat like lime when slacking. It is almost as caustic to the taste as potash.

SECTION 2.—EARTHS WHICH ARE NOT ALKALINE.—It is conjectured from analogy, that these earths consist of peculiar bases, united to oxygen. These imaginary bases may be called metalloids also. Some chemists, however, have placed silex among acidifiable substances not metallic, and denominate it silicon.

PRINCIPLE 9.—OF SILEX.—Silex, the most abundant substance known to us, constitutes the largest proportion of most rocks and soils. No rock stratum, except some lime rocks, is destitute of silex: quartz crystals are almost pure silex. Most gems, excepting the diamond, the pearl, and the sapphire family, are chiefly composed of silex. By combining it with an alkali, and then separating the alkali with an acid, it may be obtained pure from its earthy compounds. Glass sometimes contains the oxyd of a metal, which may be tarnished by hydro-sulphuret of ammonia.